

Estimation and Initialization of Atlantic MOC Using GFDL's CDA System Based on Perfect Model Argo Network

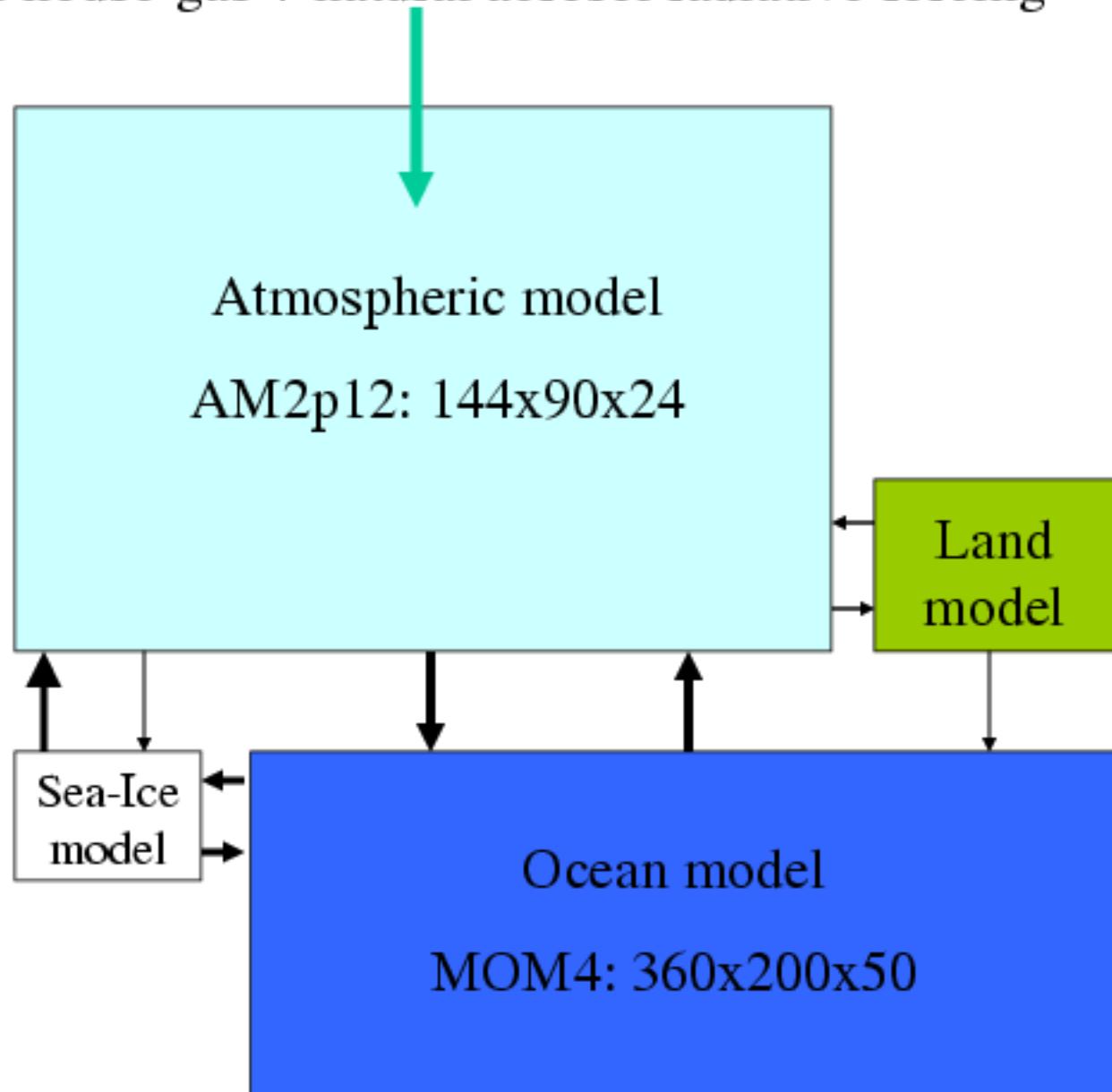
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GFDL/NOAA, Princeton University

OUTLINE

- ✓ Brief Introduction of GFDL's Coupled Data Assimilation System
- ✓ Idealized Twin Experiments: Can we reconstruct Atlantic MOC from the Argo network? What are issues?
 - Only using top 500 m ocean temperature measurements
 - Only using top 500 m ocean temperature and salinity measurements
 - Using Argo measurements (down to 2000 m deep for temperature and salinity)
- ✓ Discussions and future directions

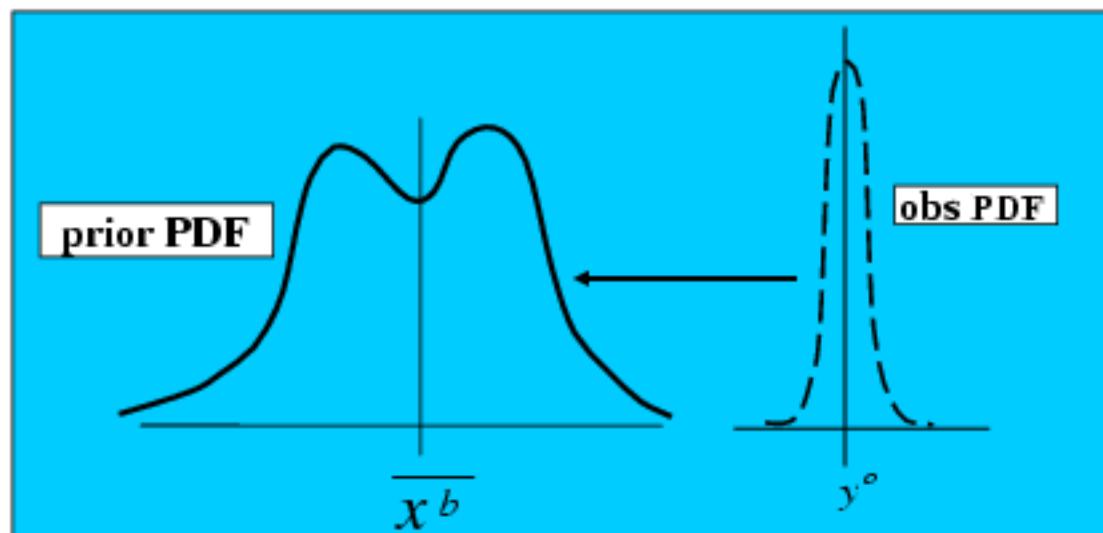
green-house-gas + natural aerosol radiative forcing



Deterministic (being modeled)

$$\frac{d\mathbf{x}_t}{dt} = f(\mathbf{x}_t, t) + \mathbf{G}(\mathbf{x}_t, t)\mathbf{w}_t$$

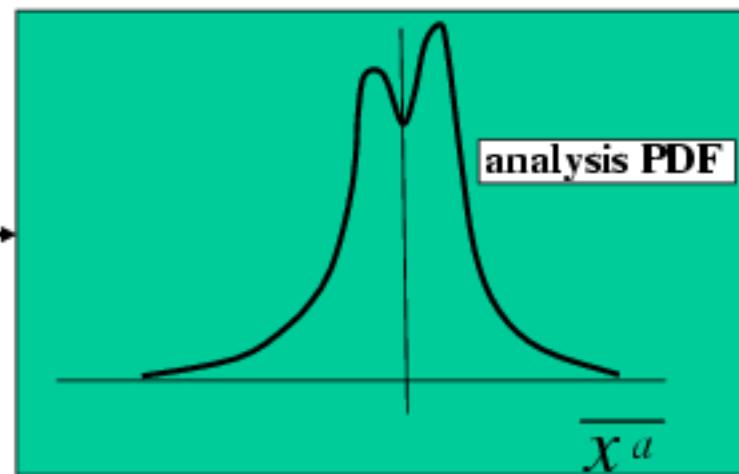
Uncertain (stochastic)



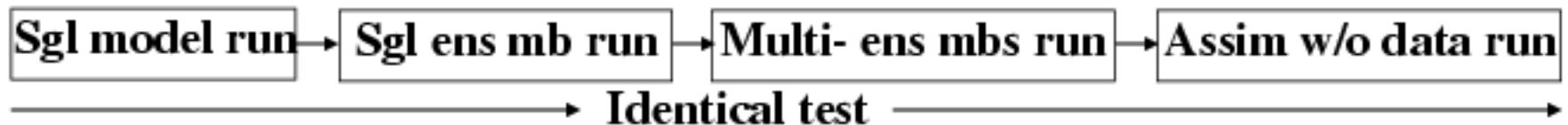
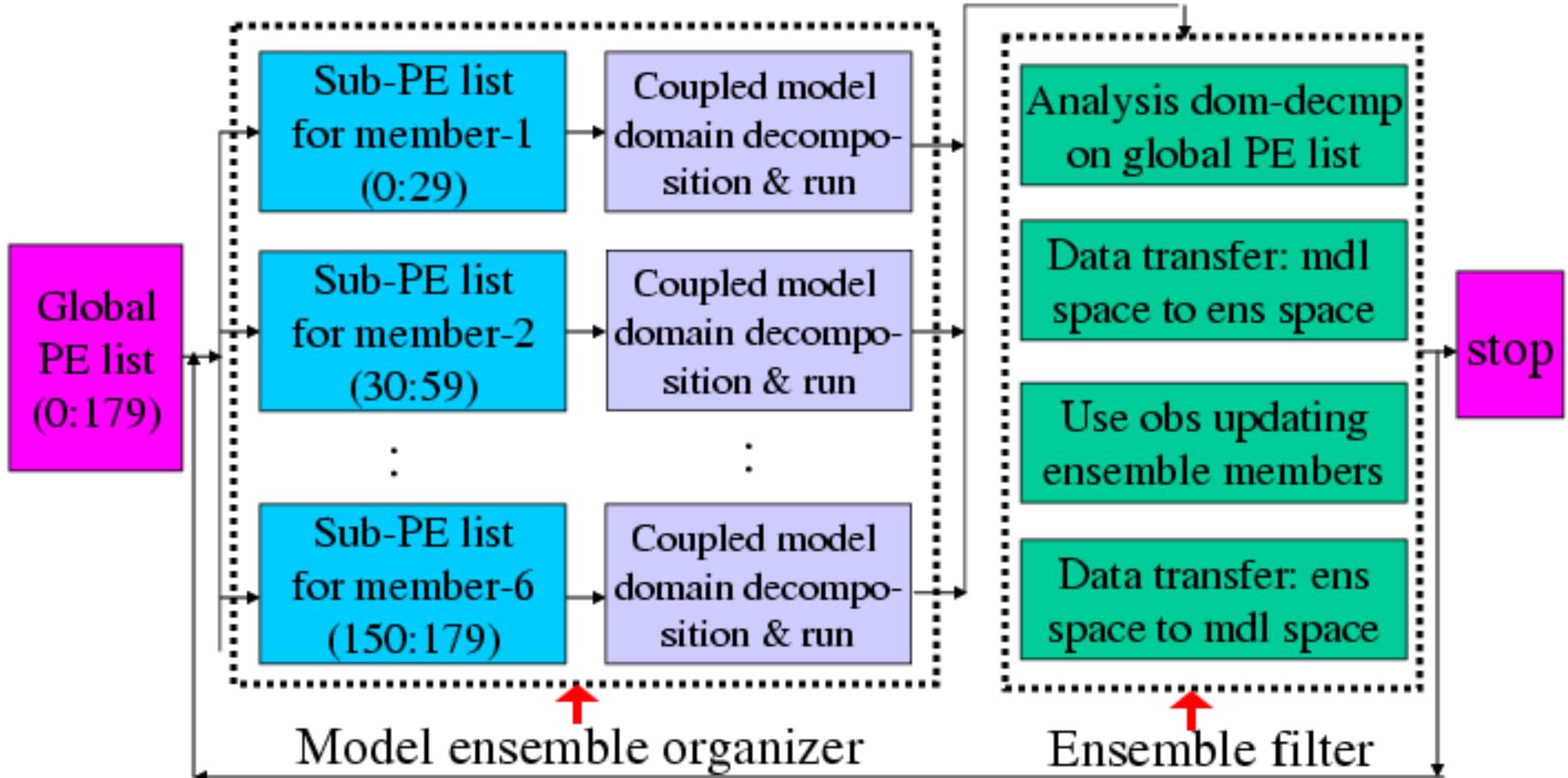
✓ Atmospheric internal variability

✓ Ocean internal variability
(model does not resolve)

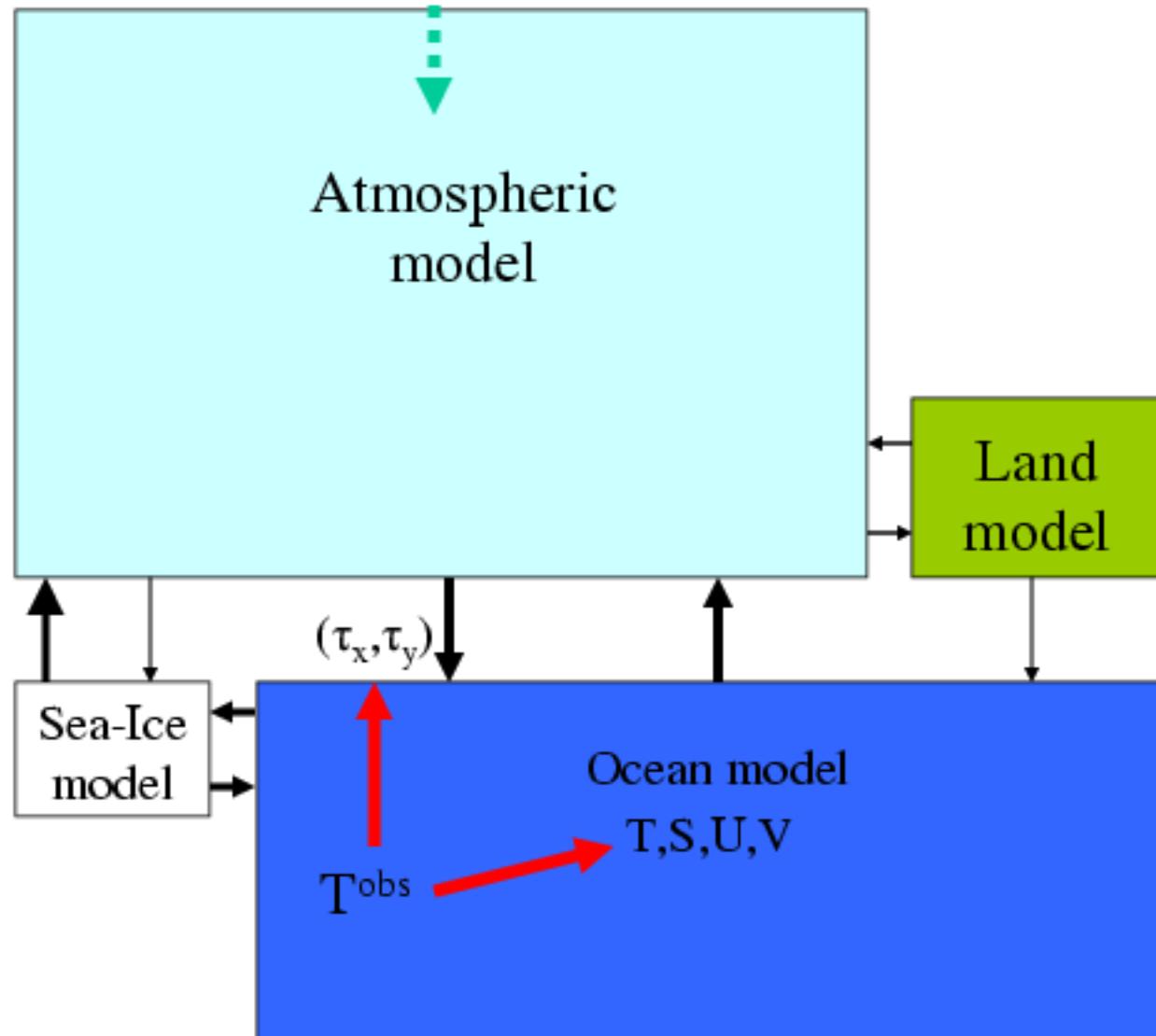
Data Assimilation (Filtering)



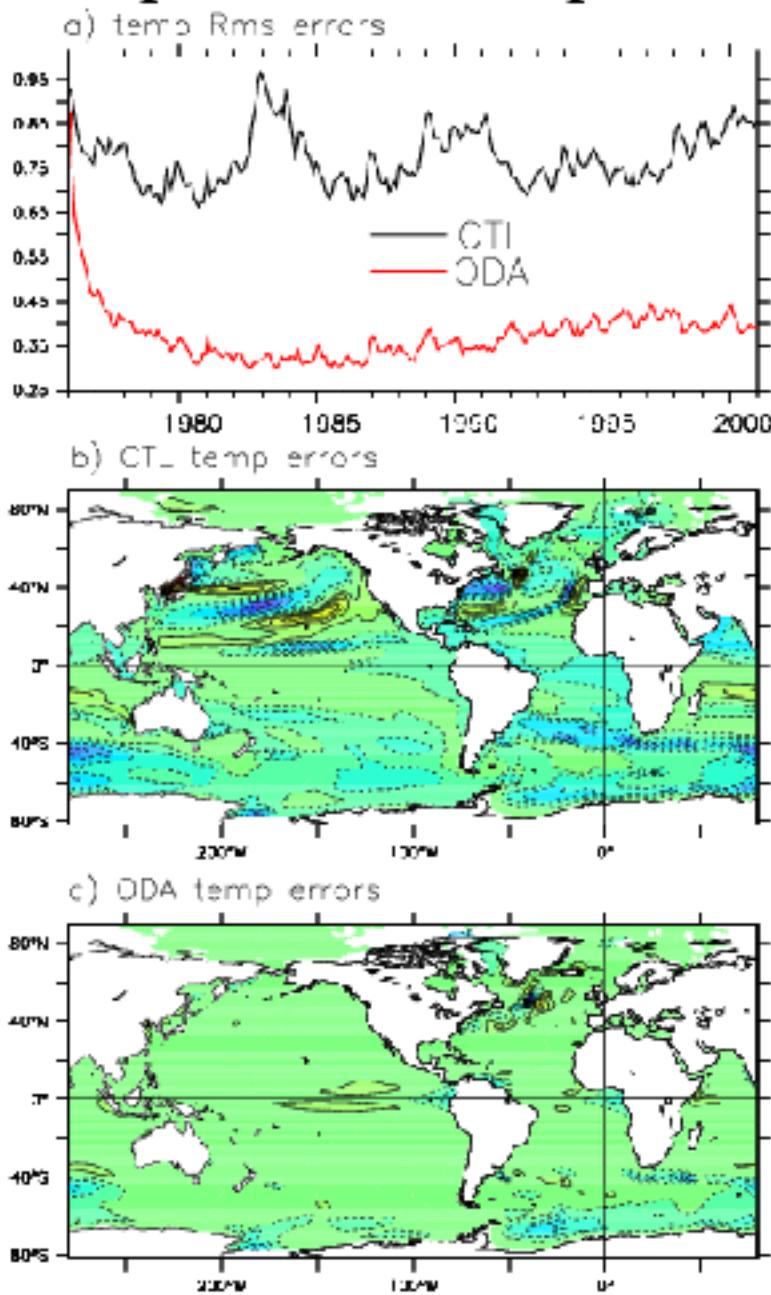
CM2 ensemble filter: PE grouping and domain decomposition



1860 GHG and NA radiative forcing



Temp errors over top 500m



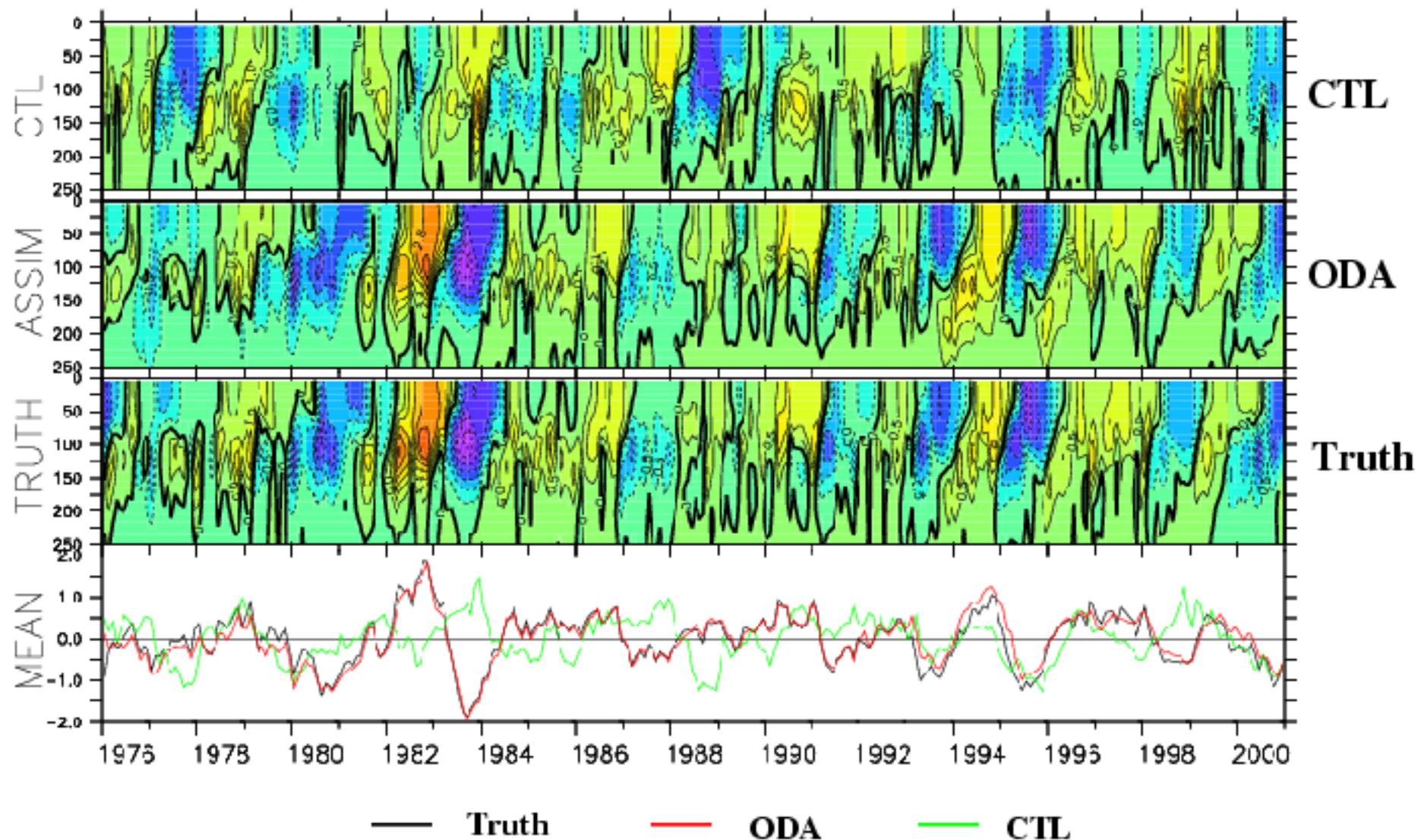
Global Rms error

CTL Averaged errors

ODA Averaged errors

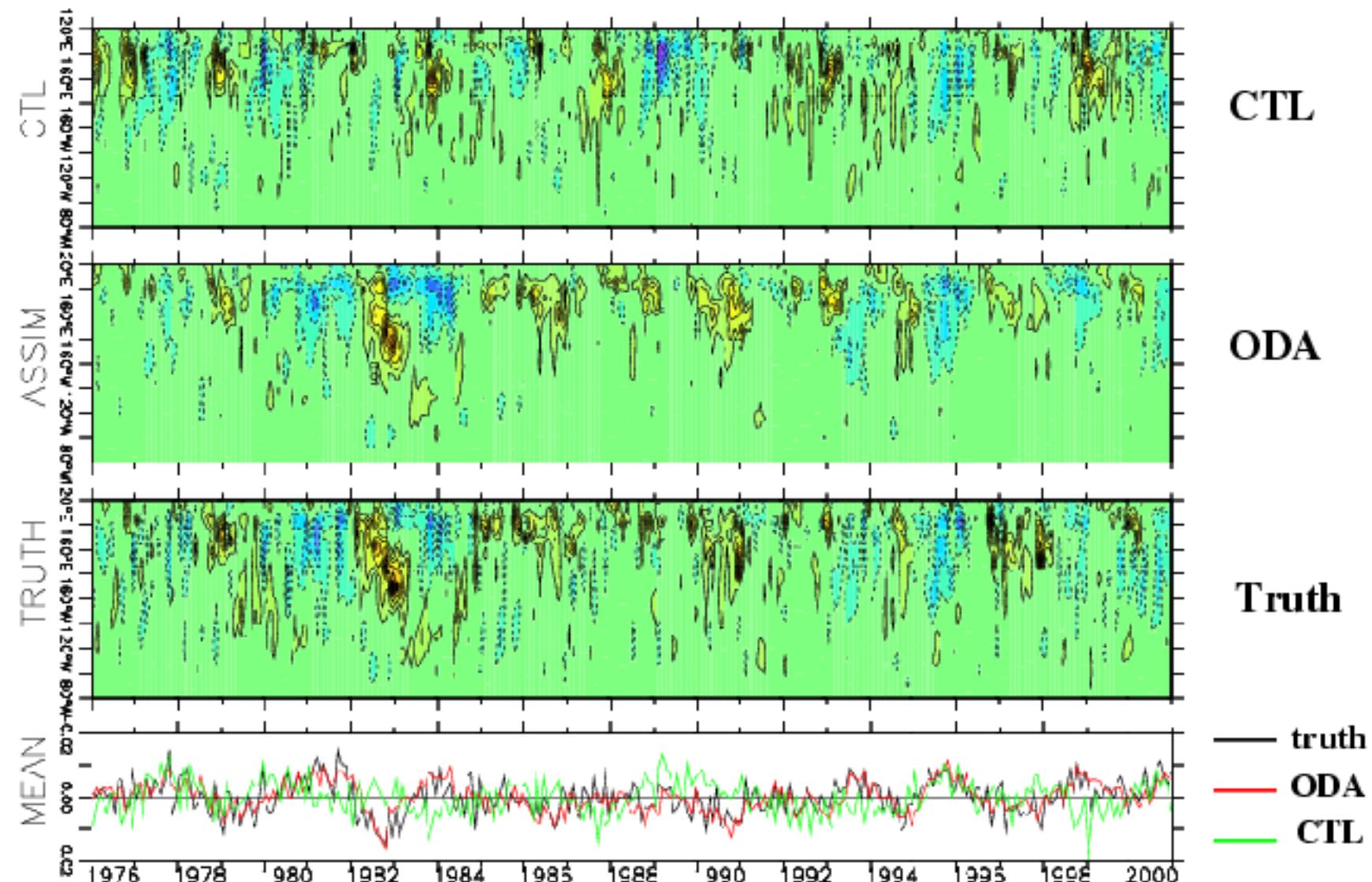
25yr climate detection: ENSO variability

1) Temperature at NINO3.4



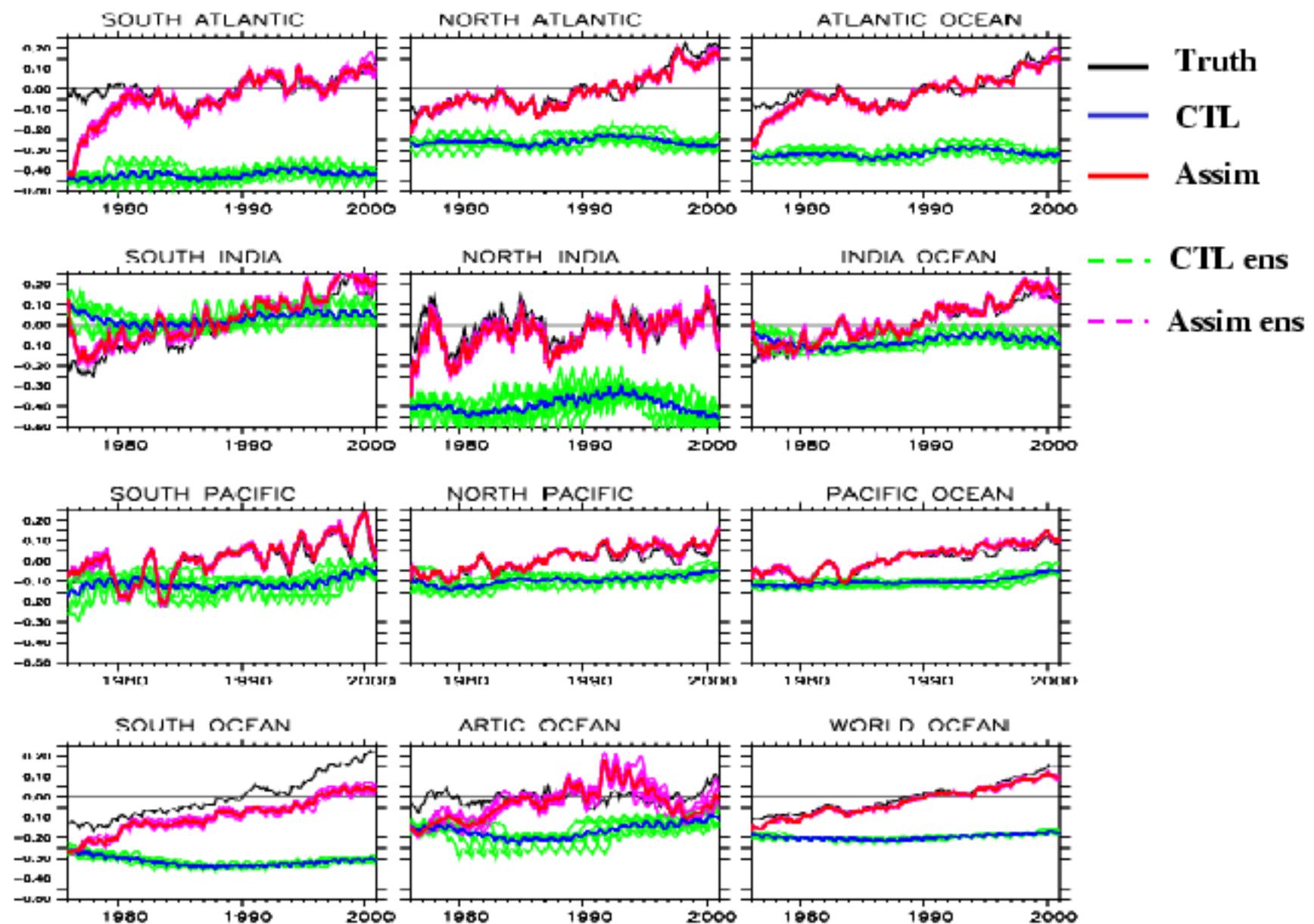
25yr climate detection: ENSO variability

2) Zonal wind stress (τ_x) at tropical Pacific (5S-5N average)



How much can we retrieve the trend of climate change?

1) Top 500 m Ocean Heat Content (Averaged Temperature) Anomalies

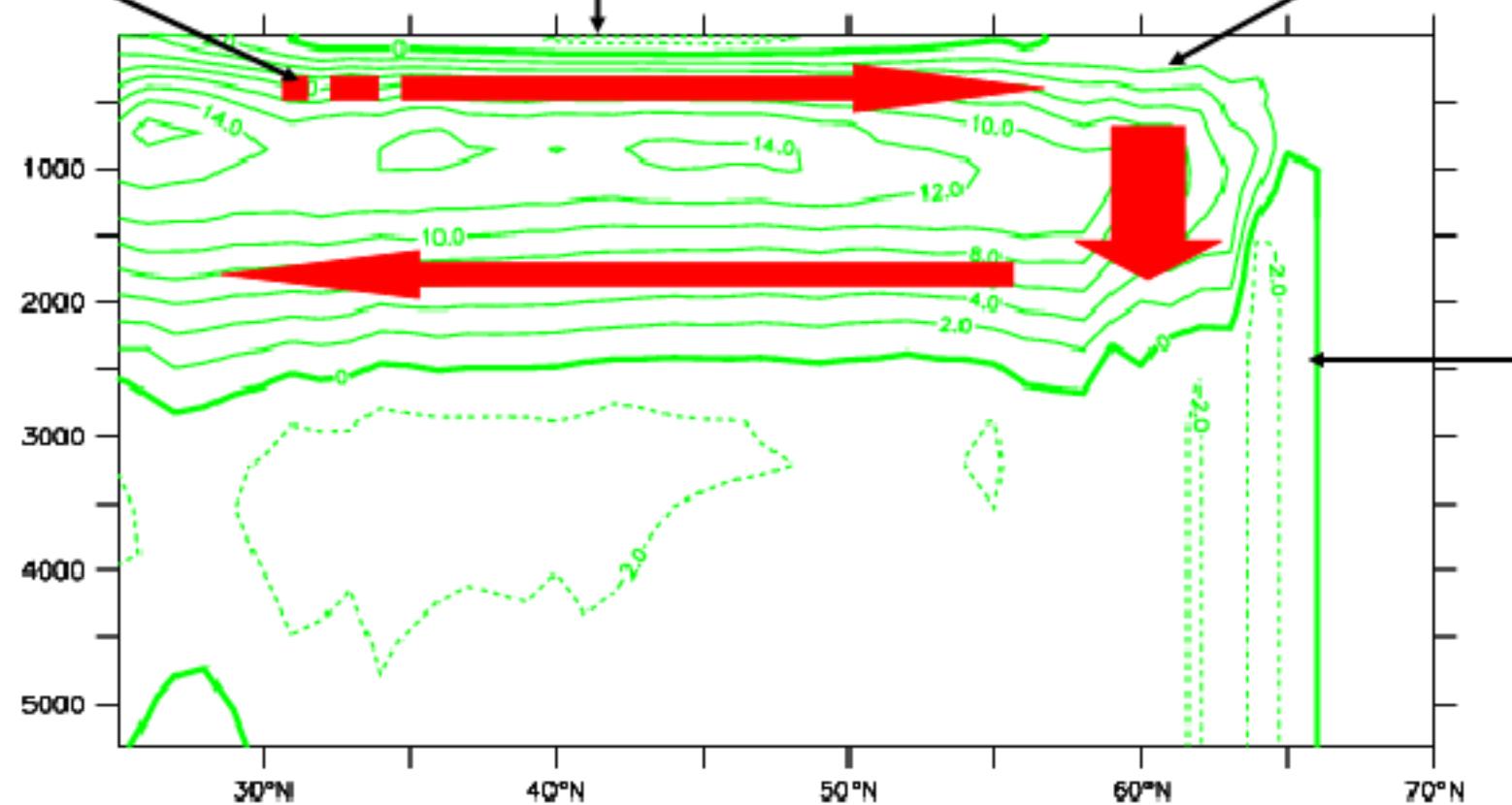


① THC's heat/salt transport

**② boundary forcing
from atmosphere**

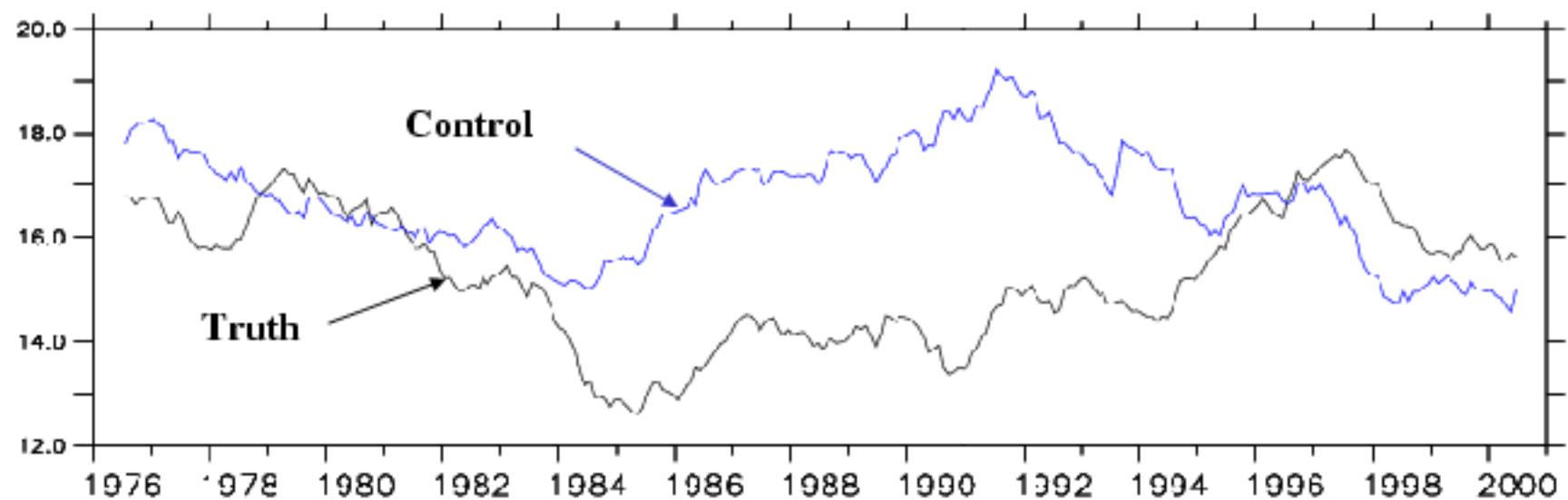
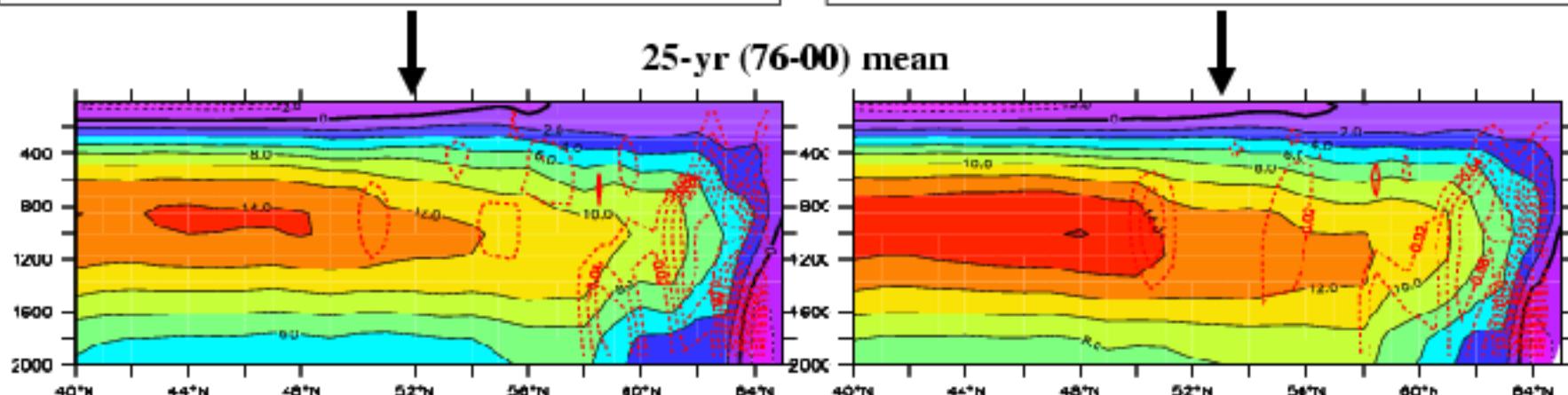
**④topography
processing**

**③fresh water forcing
from ice & runoff**



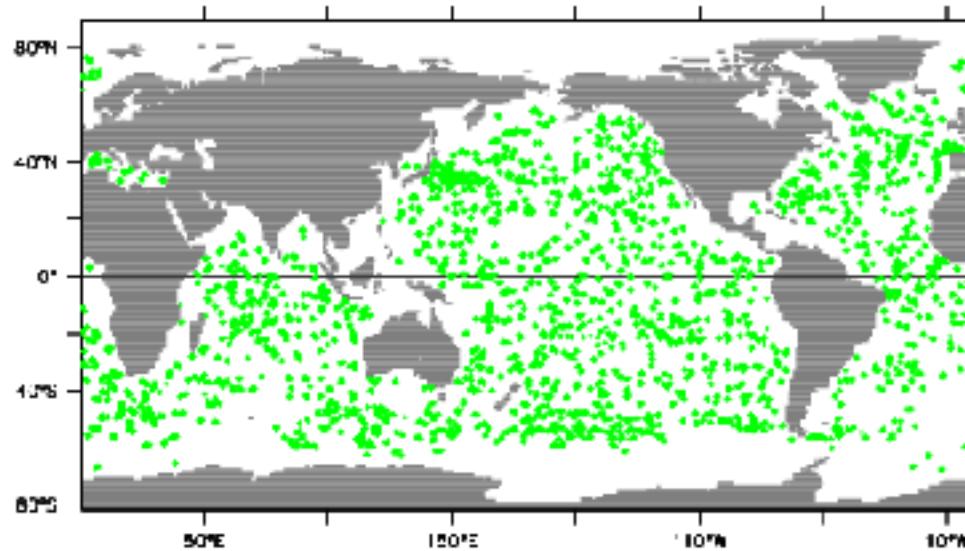
**Truth: Historical radiative forcings
run from 1861-2000, initializing
the model from 300-yr spinup
using 1860 radiative forcings**

**Control: Historical radiative forcings
run from 1861-2000, initializing
the model from 380-yr spinup
using 1860 radiative forcings**

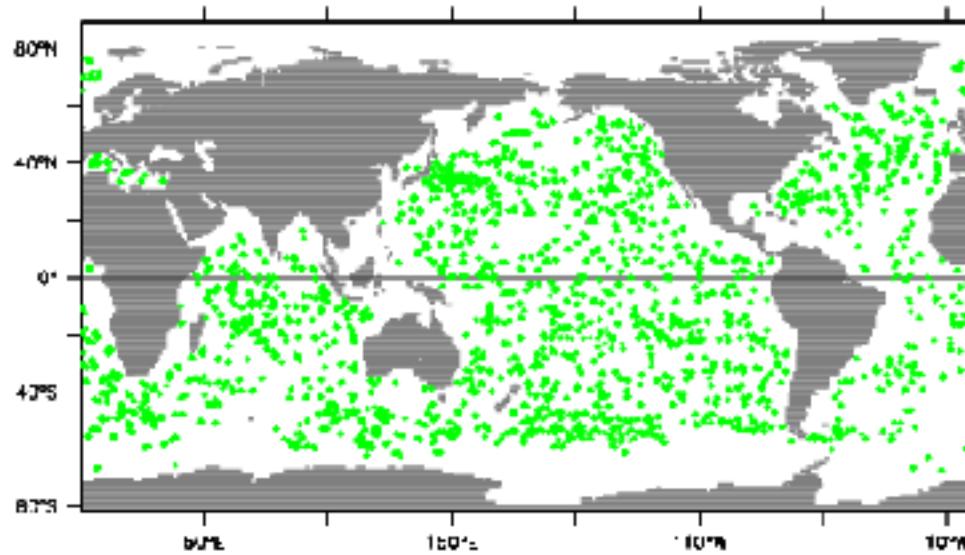


2005 June Argo network

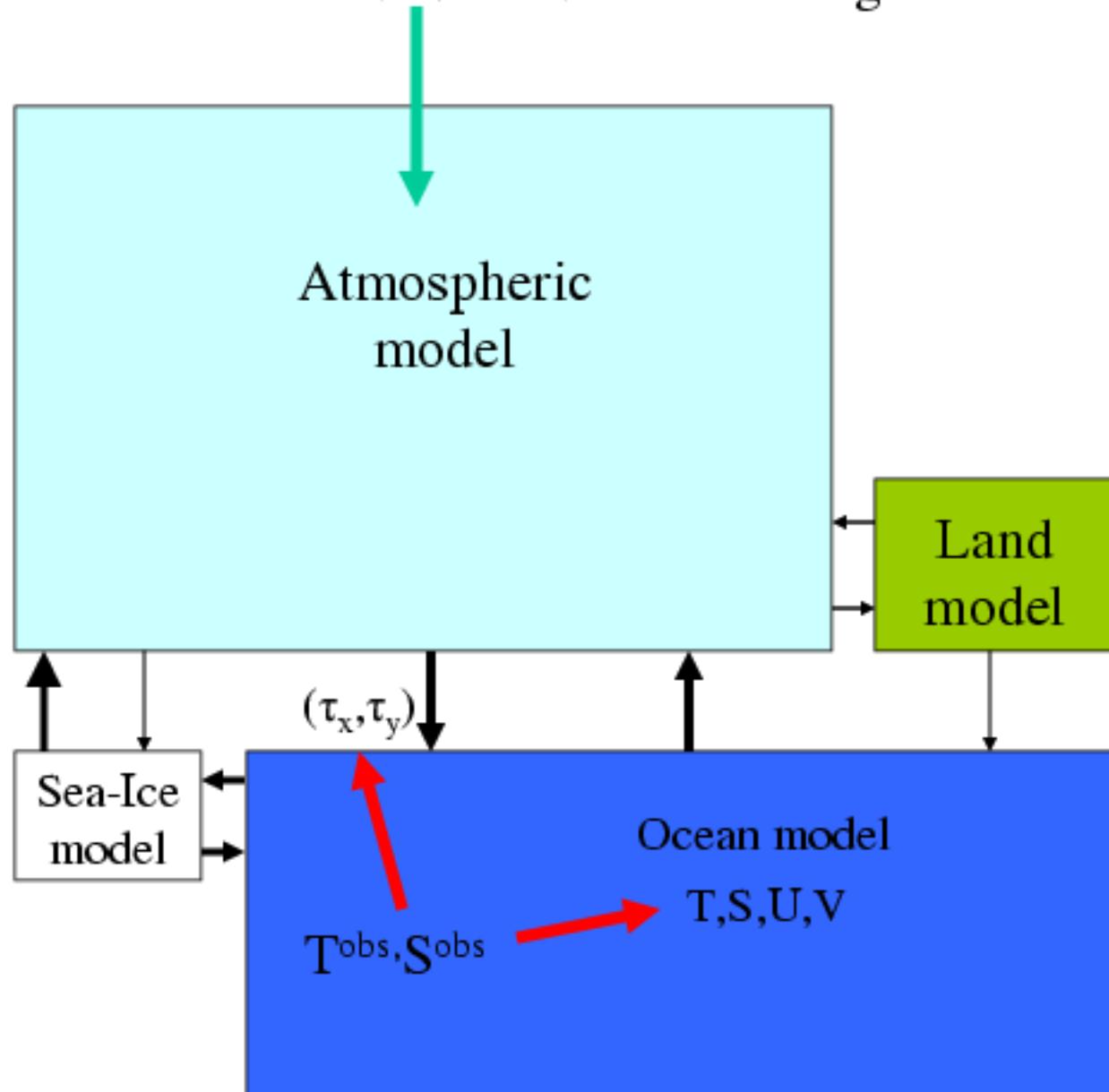
Temperature



Salinity

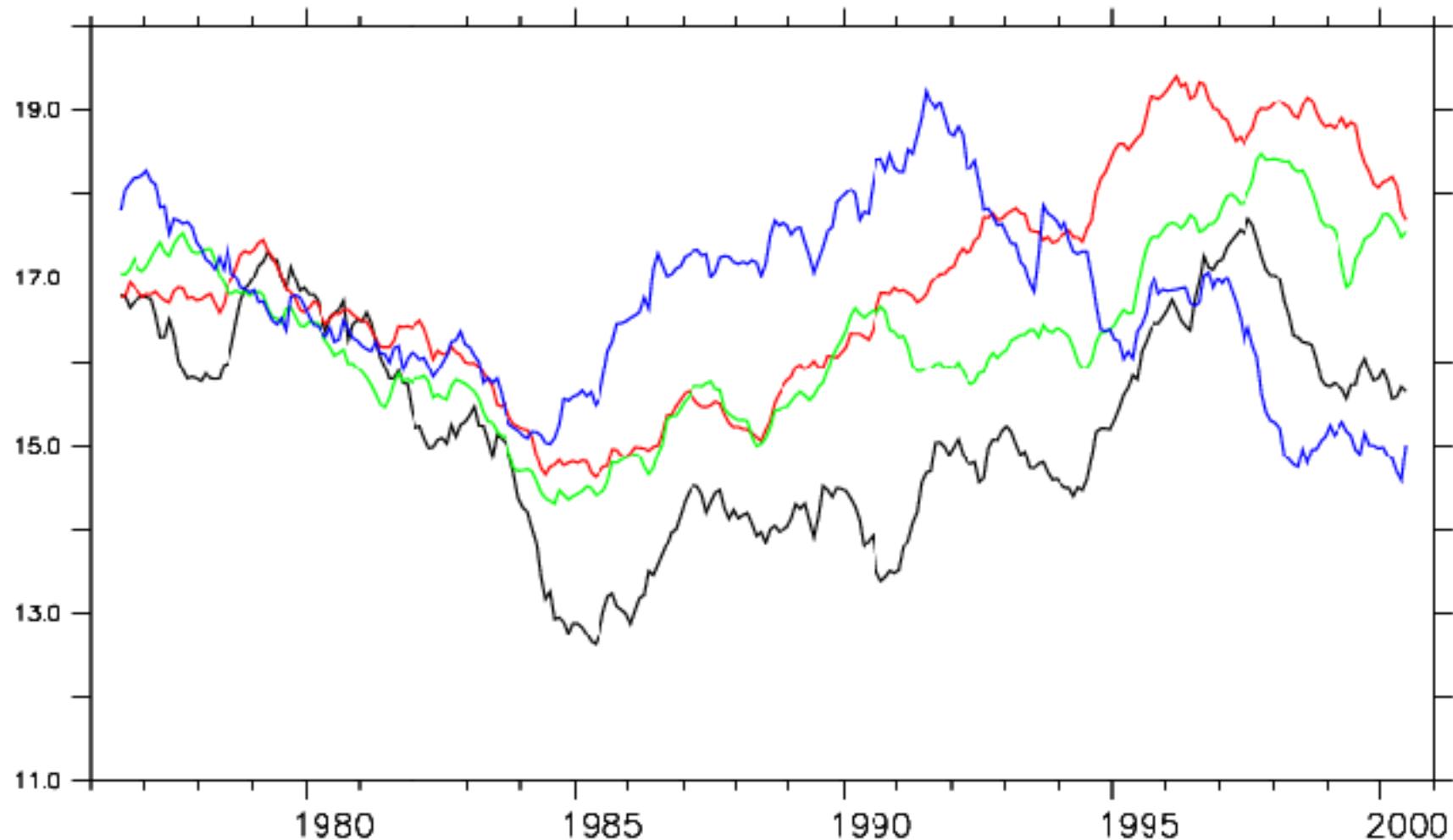


1860 GHG and NA radiative forcing

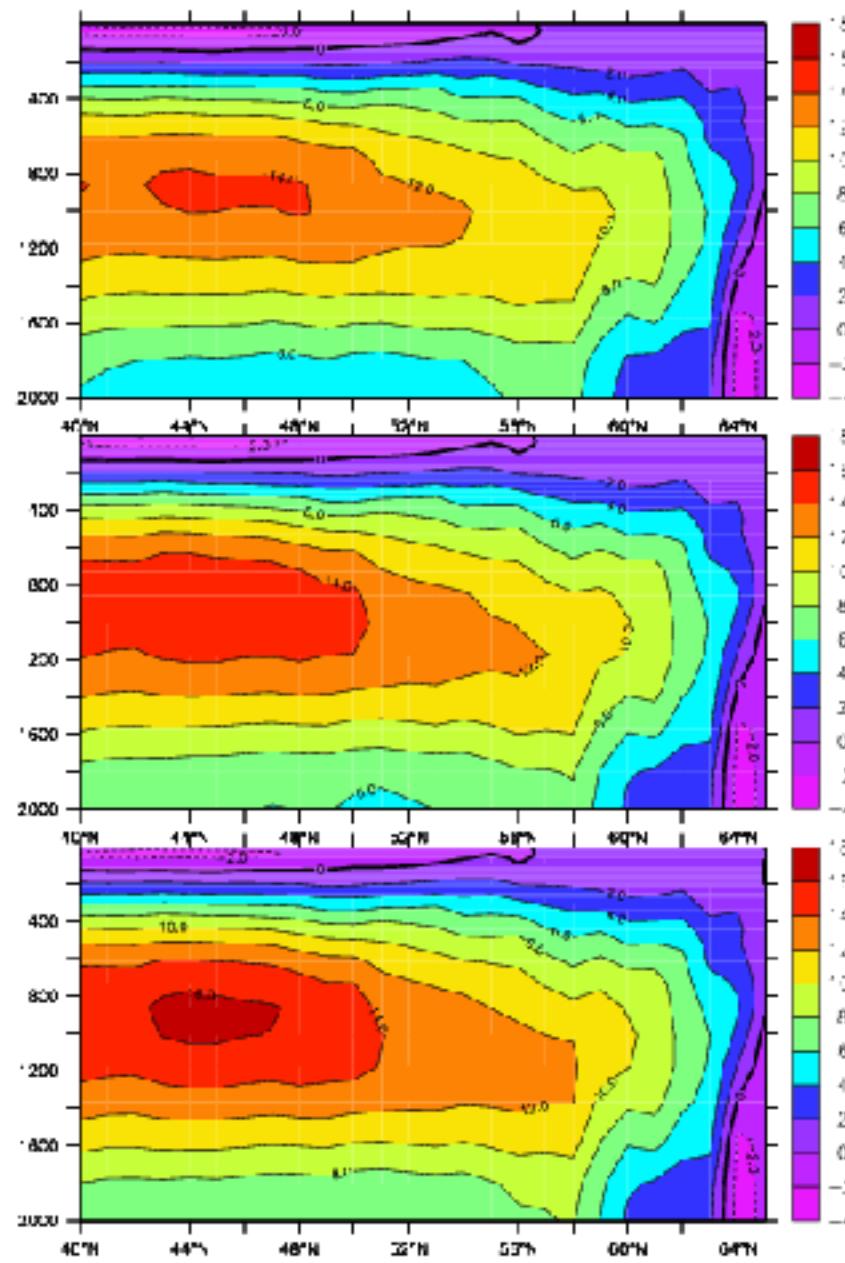


13-point running average of $\text{Max}(\psi)$ in (40n:70n)

— Truth — ODA (500m) T+Cov(T,S)
— Control — ODA (500m) T,S +Cov(T,S)



25-yr Time Mean of the Atlantic MOC



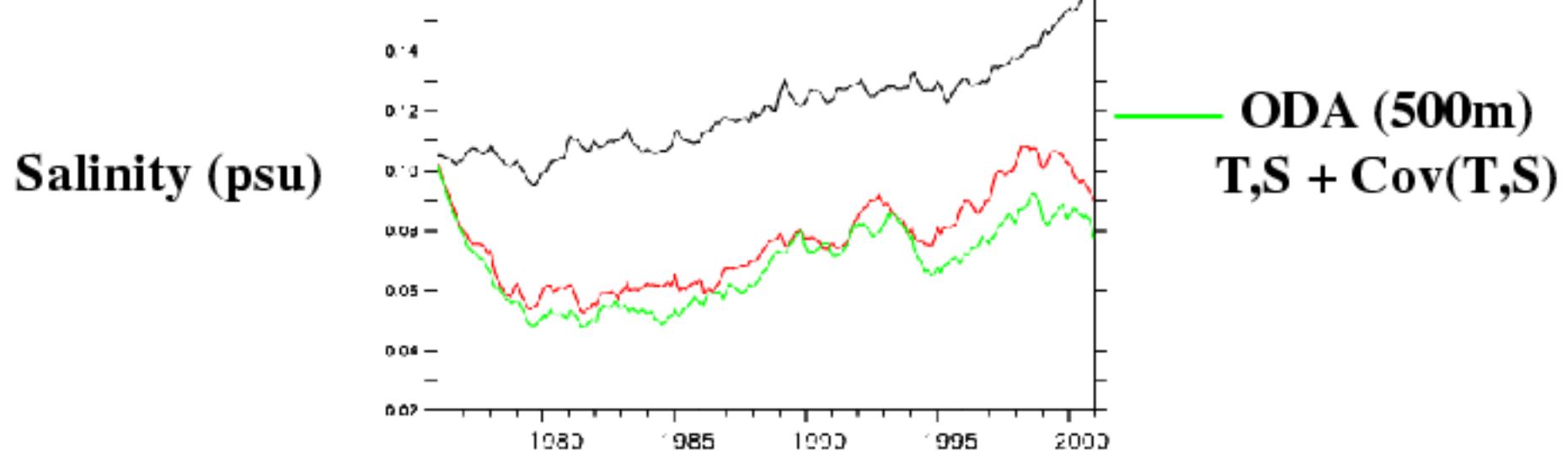
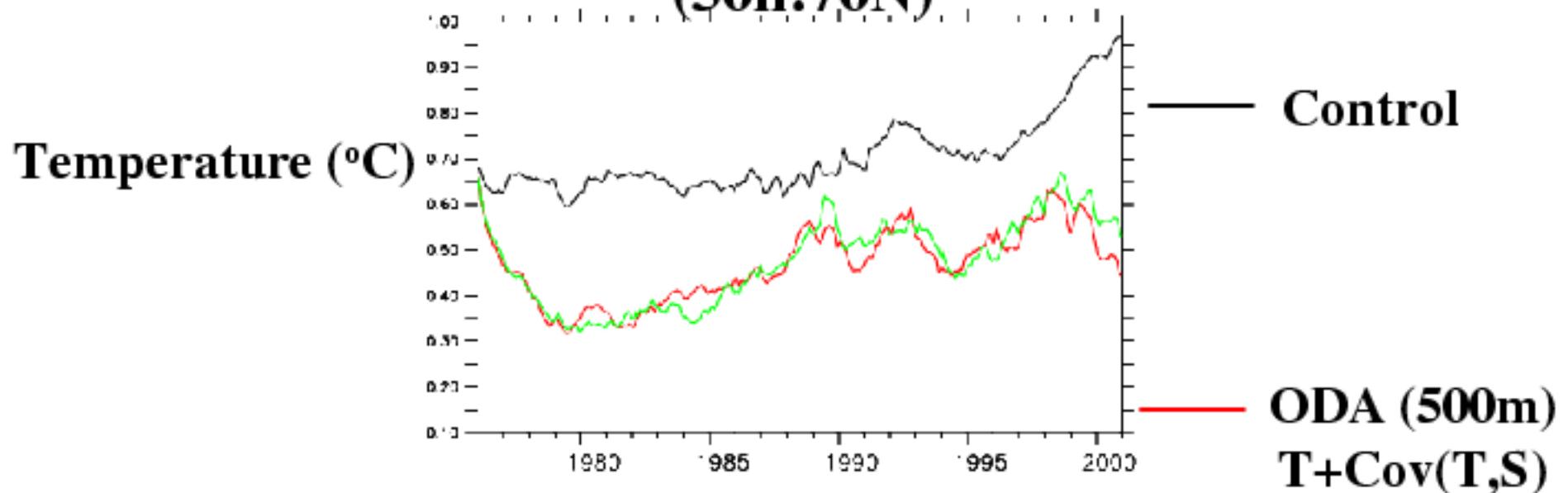
Truth

ODA (500m)
T,S + Cov(T,S)

ODA (500m)
T + Cov(T,S)

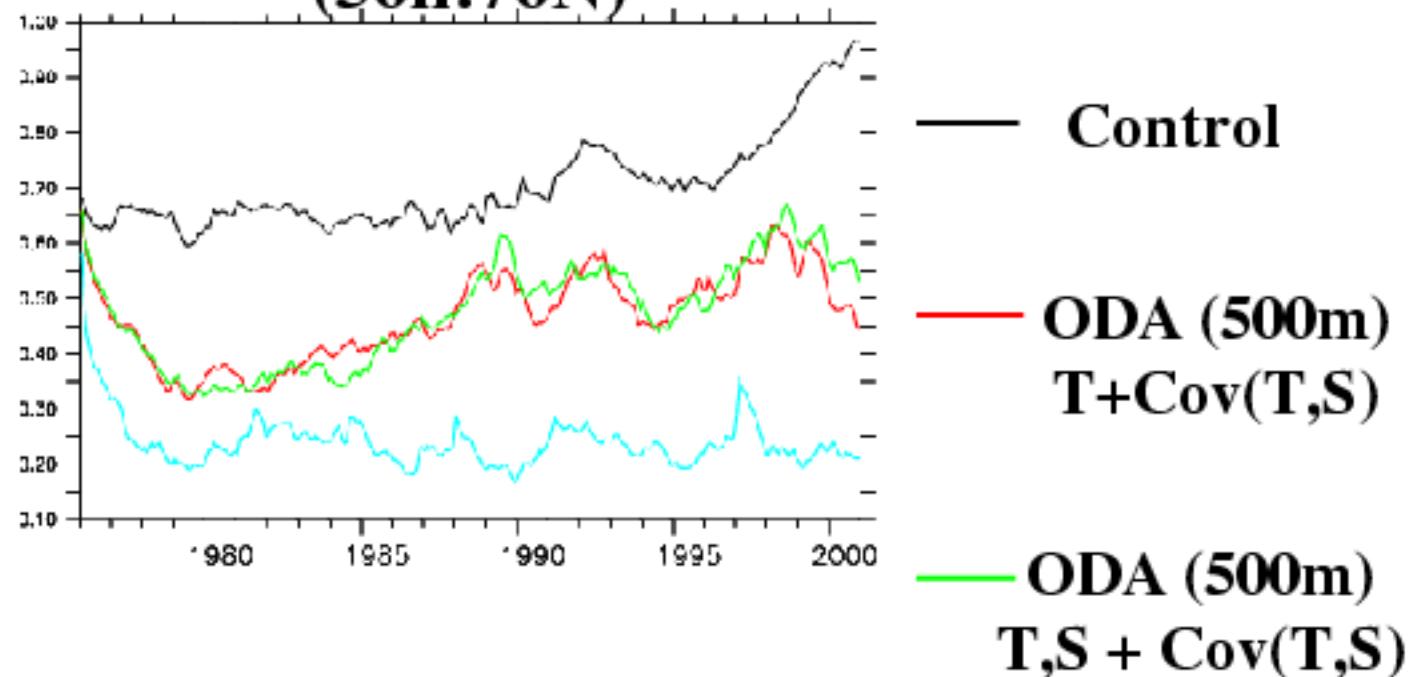
Root mean squared errors of top 2000 m north Atlantic

(30n:70N)

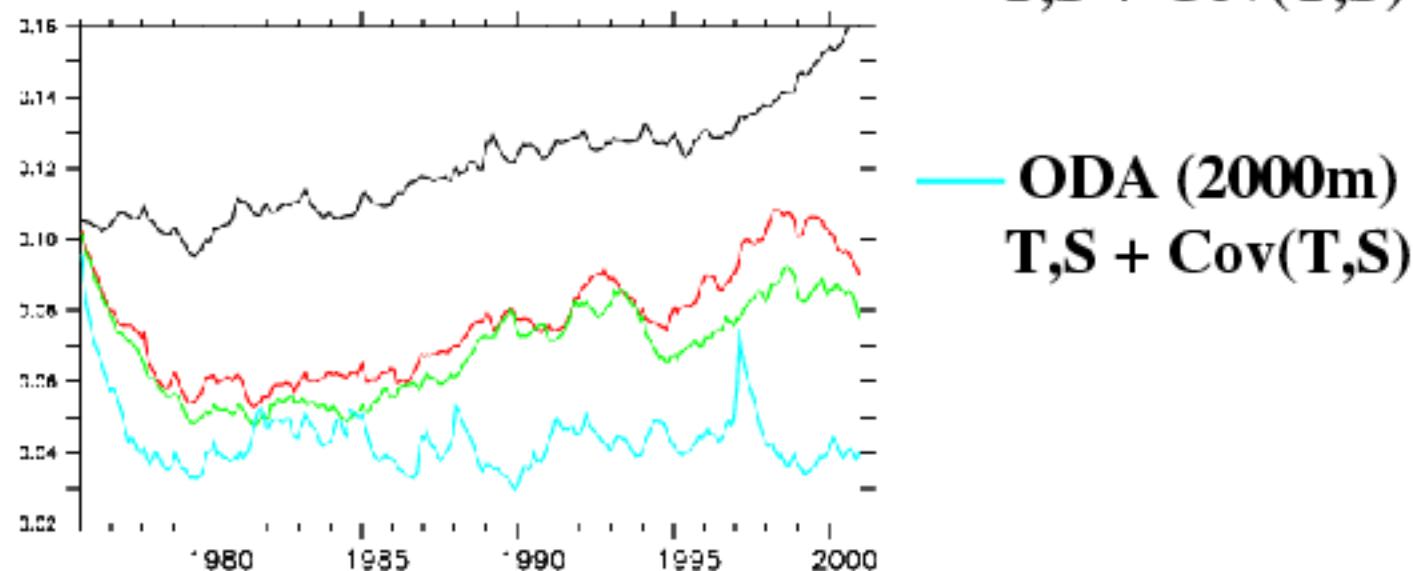


Root mean squared errors of top 2000 m at north Atlantic (30n:70N)

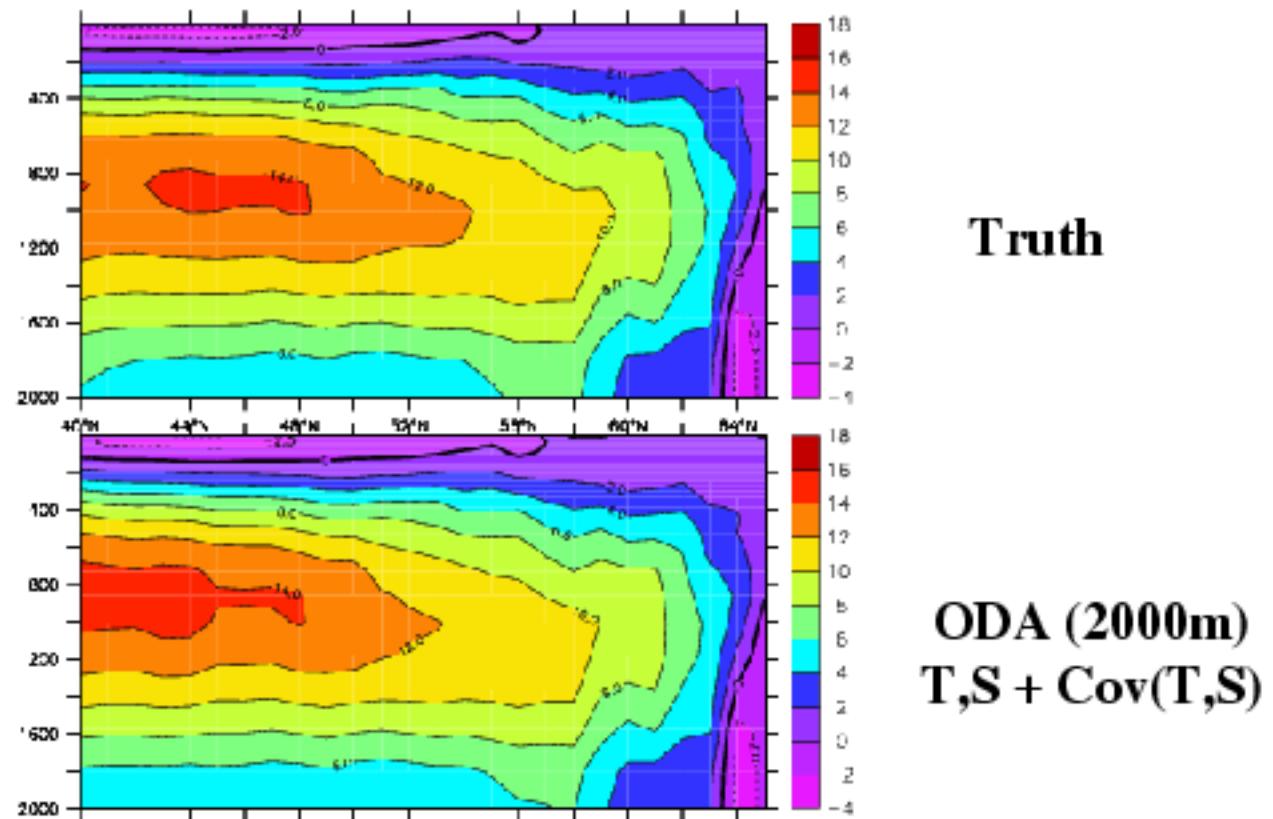
Temperature ($^{\circ}\text{C}$)



Salinity (psu)

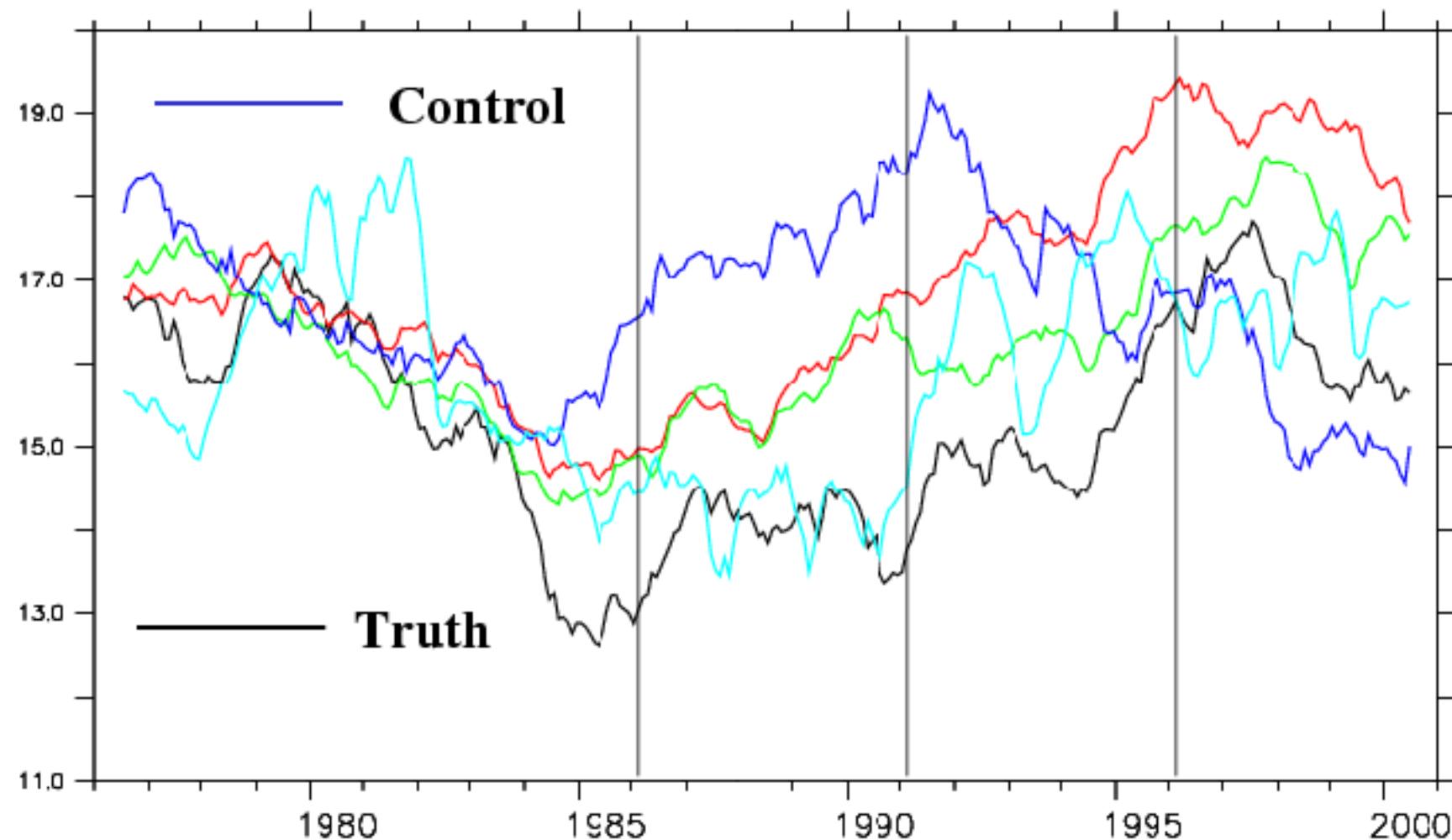


25-yr Time Mean of the Atlantic MOC

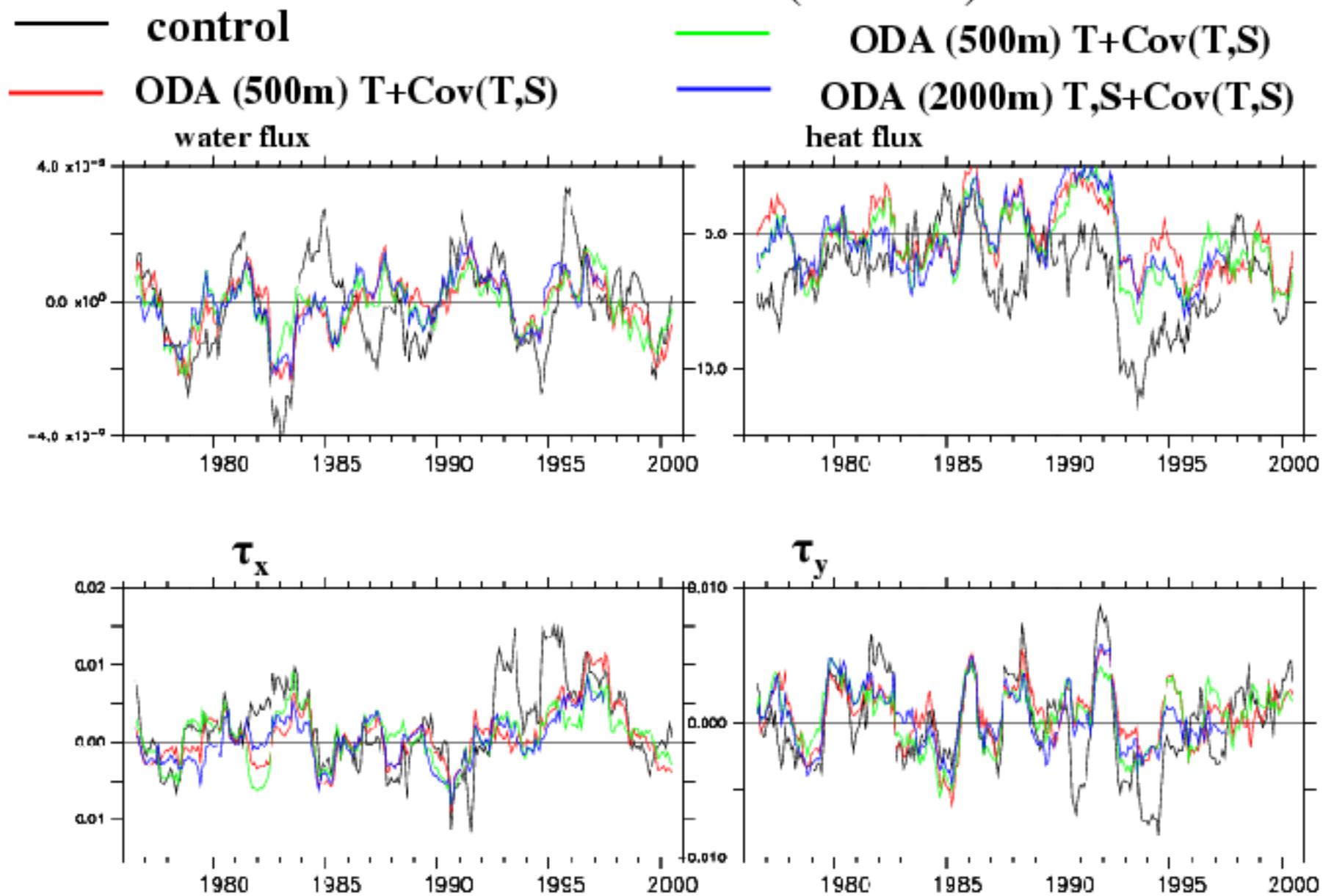


13-point running average of $\text{Max}(\psi)$ in (40n,70n)

— ODA (500m) — ODA (500m) — ODA (2000m)
T+Cov(T,S) T,S +Cov(T,S) T,S +Cov(T,S)



Timeseries of regionally-averaged errors over north Atlantic (30n:70n)



Remarks

- ✓ Based on 2005 Argo network and perfect model framework, the GFDL's ensemble CDA system is able to reproduce the large time scale (decadal) trend of the Atlantic MOC by assimilating both ocean temperature and salinity.
- ✓ The variability of the Atlantic MOC is associated with large-scale THC's heat/salt transport, sea surface forcing from atmosphere, fresh water forcing from ice and runoff and their interaction with the NA topography. Thus, atmospheric data constraint in the next phase of the CDA experiments would improve the estimate of interannual timescale variability of the Atlantic MOC.

GHG + NA radiative forcing

